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OBSERVATIONS ON THE ECOLOGY AND REPRODUCTION OF *SMINTHOPSIS LEUCOPUS* (MARSUPIALIA:DASYURIDAE)

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Abstract: The results of trapping carried out over 5 years support the observations of others that *Sminthopsis leucopus* is found in a wide variety of habitats, and that capture rates are low. At Sandy Point Naval Reserve, Victoria *S. leucopus* was found in 2 vegetation associations (foredune complex and *Eucalyptus viminalis* woodland); it was most often captured in the foredune complex. Trapping success was never higher than 3.75%.

Field and laboratory studies on reproduction show that *S. leucopus* is a seasonally restricted breeder. Males survive beyond the time of birth of the young but breed in only one season. Females may breed in more than one season.

Within *Sminthopsis* fourteen species are recognised (Archer 1981, McKenzie & Archer 1982) but only four have been the subjects of studies on ecology and reproduction. At the time the study reported here was carried out observations had been made on reproduction in *S. crassicaudata* by Martin (1965), Ewer (1968), Godfrey (1969a), Smith and Godfrey (1970) and Godfrey and Crowcroft (1971), and in *S. macroura* (as *S. larapinta*) by Godfrey (1969b). Their findings have been summarised by Woolley (1973). More recently, observations on reproduction in *S. murina* have been made by Fox and Whitford (1982), and aspects of the ecology of 3 species studied. A comprehensive study of the ecology of *S. crassicaudata* has been carried out (Morton 1978 a, b, c) and observations made on the distribution and habitat of *S. leucopus* and *S. murina* (Morton *et al.* 1980) and habitat requirements of *S. murina* (Fox 1982). Some information on range length of *S. leucopus* has been obtained by Cheetham and Wallis (1981).

S. leucopus occurs in eastern New South Wales, southern and southeastern Victoria and Tasmania (Green 1972, King 1980, Morton *et al.* 1980). In Victoria the species has been recorded from a variety of habitats including sand dune complex, heath, woodland, open forest and semi-cleared areas (Land Conservation Council Reports 1972a, 1972b, 1973, 1974, 1976, 1980, 1982, Callinan & Gibson 1977). The vegetation in 17 habitats has been described; 15 by Morton *et al.* (1980); one, by Cheetham and Wallis (1981) and one by Menkhorst and Beardsell (1982). In New South Wales *S. leucopus* is found in heathland (King 1980) and in Tasmania, in diverse habitats which include coastal tea tree, dry sclerophyll forest and rain forest (Green 1972). The present distribution is restricted to within 150 km of the coast in southern Victoria and southeastern New South Wales (Morton *et al.* 1980); in Tasmania it is found in coastal areas and in the central highlands up to an altitude of 600 m (Green 1972). Although considered rare in Victoria (Frankenberg 1971) and Tasmania (Green 1972), Morton *et al.* (1980) suggest that the species may not be as uncommon as previously thought. Little is known of its habits. In Tasmania, nests of either shredded bark or bark and leaves containing *S. leucopus* have been found in fire wood stacked in the bush and in the lining of an abandoned bus (Green 1972) and '45 feet up in the side of a gum tree' (Sharland 1962). Females with small young in the pouch have been captured in October (Green 1972, Cheetham & Wallis 1981).

An opportunity to study this little known species was provided by the finding of a population close to Melbourne in an area relatively free from disturbance. In 1968, 6 specimens were collected from the foredune area of the Sandy Point Naval Reserve, Mornington Peninsula, by the Victorian Fisheries and Wildlife Division, and in 1971 a further 2 specimens were collected in the same area by the Mammal Survey Group of the Victorian Field Naturalists Club (J. Seebeck pers. comm.).

The study was carried out from November 1971 to March 1975. Initially trapping was carried out to determine the preferred habitat of *S. leucopus* in the study area and to obtain specimens for a laboratory study of reproduction. In the course of this work it was found that several other small mammals, including *Antechinus stuartii*, *Rattus lutreolus* and *Mus musculus*, occurred in the study area. Later, the effectiveness of different types of traps was tested at the same time as a more thorough study was made of the habitat preferences of the small mammals in the study area. This was followed by a study of the distribution and home range of the small mammals in an area of the habitat preferred by *S. leucopus*. The trapping study is presented in a chronological sequence because methods changed in response to observations made in preceding years.

ECOLOGY OF *S. LEUCOPUS*

The Sandy Point Study Area

The study area (Fig. 1A) lies in the sand dune region of the Sandy Point Naval Reserve. Four major vegetation associations, *viz.* the foredune complex, *Leptospermum laevigatum* scrub, *Eucalyptus viminalis* woodland and *Banksia integrifolia* woodland, occur within it. The

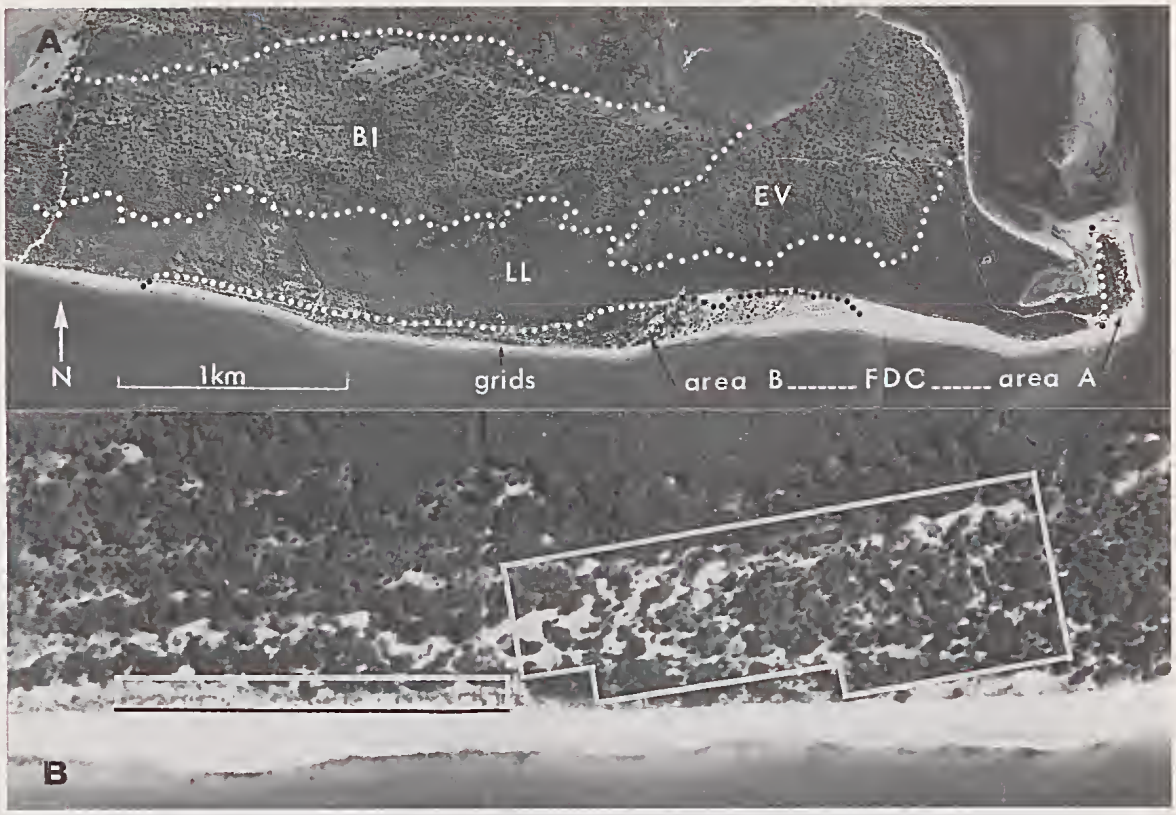

Fig. 1 – A, aerial photograph of part of the Sandy Point Naval Reserve showing the boundaries of the four vegetation associations and the location of the trapping grids in the study area. FDC = foredune complex, LL = *Leptospermum laevigatum* scrub, EV = *Eucalyptus viminalis* woodland, Bl = *Banksia integrifolia* woodland. B, the positions of the trapping grids in area B of the foredune complex. Small grid 100 × 20 m; large grid 280 × 100 m (north and east boundaries).

foredune complex, found in two areas (A and B), carries *Ammophila arenaria-Spinifex hirsutus* grassland on the seaward side. Moving inland this community is replaced by low shrubs of *Acacia sophorae* and *Leptospermum laevigatum*. Behind this is the dense *L. laevigatum* scrub. The boundaries of these vegetation associations are shown in Figure 1A, and the location of the trapping grids set up within area B of the foredune complex in Figure 1B. A description of the fire and clearing history, vegetation and soils of coastal sands in the reserve and details of the plant species occurring in each of the vegetation associations can be found in Robin and Parsons (1976).

Trapping November 1971-August 1972

Between November 1971 and August 1972 trapping was carried out in 3 of the 4 vegetation associations in the study area. Both large (23 × 8 × 9 cm) and small (16 × 5 × 6 cm) Sherman aluminium box traps and Tomahawk 1.25 × 2.5 cm mesh wire traps (40 × 13 × 13 cm) were used. The Sherman traps were baited with a mixture of peanut butter, bacon and walnuts and the wire traps with either the mixture or raw meat. Trapping was done in the months of November and December 1971 and January, June, July and August 1972. In the first 3 months traps were set in the foredune complex (Area A), and in *L. laevigatum* scrub and *E. viminalis* woodland close to the vehicle track to the point, which can be seen in Fig. 1A; in the last 3 months they were set only in the foredune complex (areas A and B). Traps were not set in a regular line or grid pattern but in selected positions, about 10 m apart, which provided cover. In each trapping period the traps were set on the afternoon of the first day and checked and reset each morning for the following 3 or 4 days. The results of trapping in 1971 and 1972 are summarised in Table 1. *S. leucopus* was only captured in the foredune complex. Eight of the ten trapped were collected for study in the laboratory; all other mammals were released immediately at the site of capture. Trapping success, expressed as the number of individuals of a species caught per 100 trap-nights, was approximately 0.5% for *S. leucopus*. All species were captured in Sherman traps but the Tomahawk traps, because of the large mesh size, captured only *R. lutreolus*.

Trapping in 1973

In 1973 the main object of trapping was to collect *S.*

TABLE 1
RESULTS OF TRAPPING IN 1971 AND 1972

Vegetation Association		No. trap-nights	No. each species trapped			
			S.l.	*A.s.*	*R.l.*	*M.m.*
Foredune complex	(A)	1027	(5)	7	20	148
	(B)	769	(5)	2	21	113
	(A + B)	1796	(10)	9	41	261
L. laevigatum scrub		180	0	1	0	4
E. viminalis woodland		333	0	18	11	4

S.l. = *Sminthopsis leucopus*, *A.s.* = *A. stuartii*, *R.l.* = *Rattus lutreolus*, *M.m.* = *Mus musculus*.
The number of *S.l.* trapped (shown in brackets) represents individuals; the numbers of *A.s.*, *R.l.* and *M.m.* may include recaptures.

leucopus to study reproduction in this species. Because *S. leucopus* had previously been trapped only in the foredune complex most trapping was carried out in this vegetation association (areas A and B), but some was done in *E. viminalis* woodland and some in *B. integrifolia* woodland. Large and small Sherman traps were used. These were baited with a live cockroach, restrained by the spring wire on the back door of the trap, and a mixture of peanut butter, bacon and honey. The traps were set in selected positions as before. Trapping was carried out in 8 periods of from 3 to 8 days duration for a total of 39 days in the months of April, June, July, August, September, October and December.

The results of trapping in 1973 are summarised in Table 2. Fourteen of the 26 *S. leucopus* captured (including 3 found dead in the traps) were removed from the field. Others when first captured were marked by clipping digit 5 of the right pes. Only 4 *A. stuartii*, which were found dead in the traps, were removed from the field; the rest were toe-clipped as above and released. The *R. lutreolus* captured were released but not marked. All *M. musculus* trapped were killed to prevent them from excluding native species from the traps. As in 1971-72, *S. leucopus* was captured only in the foredune complex. Again, there was a low overall trapping success (approximately 0.8%) for *S. leucopus* individuals, even though a different bait was used. The large and small Sherman traps were equally effective in the capture of *S. leucopus* (27 and 31 captures respectively), *A. stuartii* (48 and 50) and *M. musculus* (35 and 30). The larger *R. lutreolus* was mainly captured in the large Sherman traps.

Figure 2 shows the number of each of the four species captured each day in each trapping period, and the number of trap nights per period, in 1973. No obvious pattern in daily trapping success in relation to the total number of days the traps were set in each period can be seen for any of the four species, but changes in trapping success between trapping periods are evident. Trapping success for *M. musculus* was highest in the first trapping period (April) and the last (December). Although the reproductive condition of the *M. musculus* was not recorded it is known that populations of *Mus* in the South West Division of Western Australia have a distinct spring-summer breeding period during non-plague situations (Chapman 1981). Since all *M. musculus* trapped were removed from the field the increase in December may have been a result of recruitment from spring breeding. The lower number of

TABLE 2
RESULTS OF TRAPPING IN 1973

Vegetation Association		No. trap-nights	No. each species trapped			
			S.l.	*A.s.*	*R.l.*	*M.m.*
Foredune complex	(A)	75	0	2(2)	21	(7)
	(B)	3170	58(26)	94(22)	17	(56)
	(A + B)	3245	58(26)	96(24)	38	(63)
E. viminalis woodland		75	0	0	0	0
B. integrifolia woodland		75	0	2(2)	0	(2)

Abbreviation of species names as in Table 1. The numbers of *S.l.*, *A.s.* and *R.l.* include recaptures. The figures in brackets represent the number of individuals.

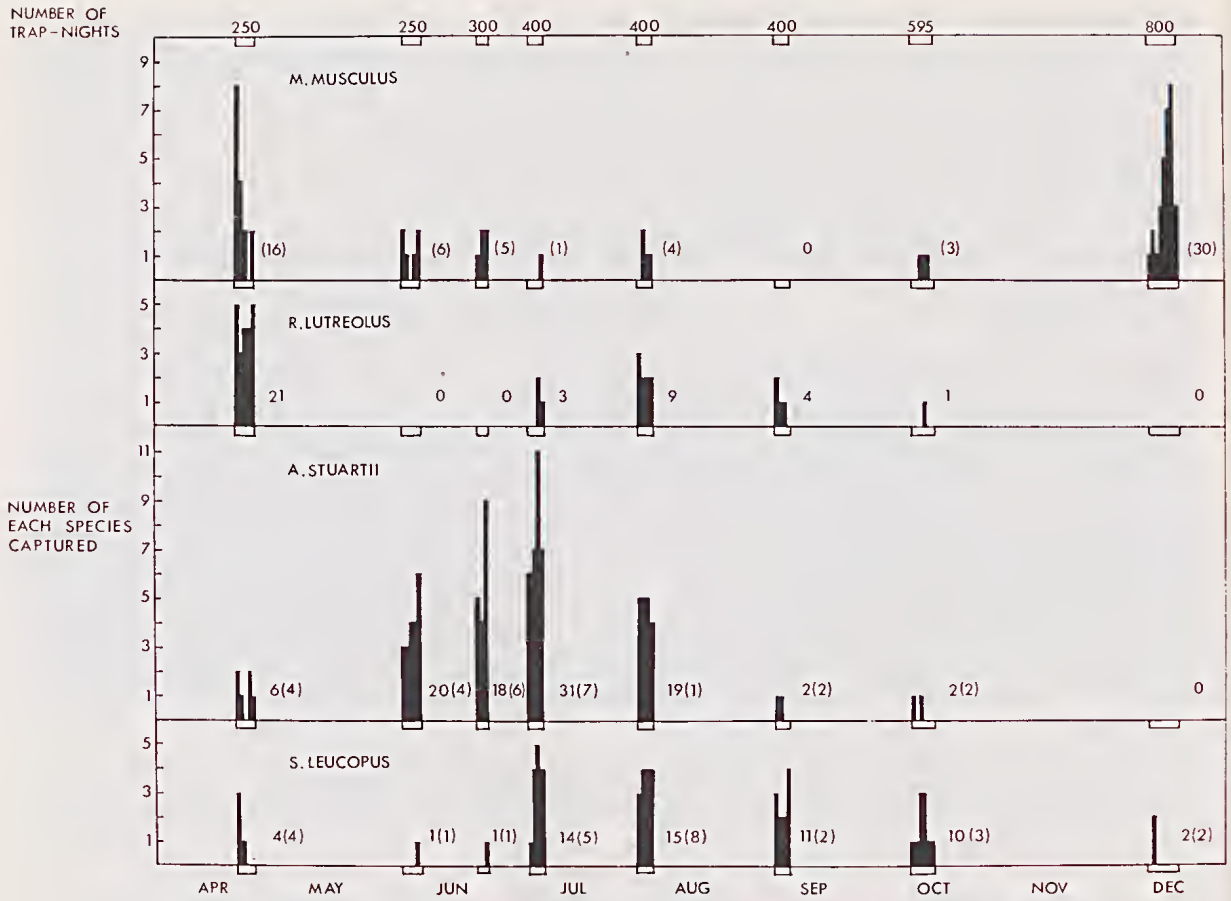

Fig. 2—The number of each species captured each day in each trapping period in 1973. The figures in brackets represent the number of individuals not previously captured. The number of trap nights in each trapping period is shown.

captures of *R. lutreolus* in each trapping period after April was probably the result of a deliberate attempt to avoid setting traps in areas in which *R. lutreolus* had been trapped, or in which their burrows were found. For *A. stuartii* trapping success for unmarked individuals was fairly constant (between 1.6% and 2.0%) from April to July but over this period trapping success calculated from the total number of captures increased from 2.4% to 7.25%. Trapping success fell in August and was very low in September and October. No animals were trapped in December when trapping effort was greatest. From April to August all *A. stuartii* trapped were males; only females (2 with pouch young) were trapped in September. This pattern of trapping success is consistent with that observed for other populations and the known life history of the species (Woolley 1966, Wood 1970). Trapping success for *S. leucopus* for both unmarked individuals (2.0%) and the total number of captures (3.75%) was greatest in August. Males were caught in all trapping periods but only 2 females were captured, one (in oestrus) in August and one (carrying pouch young) in October. These observations will be further considered below in relation to the pattern of reproduction in this species.

Trapping in 1974

Trap effectiveness and habitat preference study

Because overall trapping success for *S. leucopus* was low in previous years when Sherman traps were used, two specially designed live traps, an Elliott box trap and a funnel trap (Fig. 3) were tested in an attempt to find a more effective trap. The Elliott trap (26×10×10 cm) was slightly larger than the large Sherman trap. It had the same treadle mechanism as standard Elliott traps but the walls and roof were made of perforated aluminium (apertures 4 mm square). The funnel trap consisted of a plastic pipe 11 cm in diameter and 31 cm deep, sealed at the base, and with a polythene funnel held in place by a removable wire handle at the top. The funnel was 7 cm deep and the aperture at the base of the funnel 3.5 cm. This trap was designed to be hung in trees or shrubs; the base was perforated to provide drainage. The effectiveness of these two new traps was compared with large Sherman traps and break-back mouse traps, the latter

sometimes being considered to be more effective in sampling some species of small mammals than live traps (see, for example, Barnett *et al.* 1976, Fox & Posamentier 1976).

Trapping was carried out in the foredune complex (area A) between 11 and 15 April, in *L. laevigatum* scrub between 19 and 23 April, in *E. viminalis* woodland between 2 and 6 May, and in *B. integrifolia* woodland between 10 and 13 May. Fifty of each of the four types of traps, baited as in 1973, were used. One of each was set at 50 sites spaced 15 to 30 m apart in each of the vegetation associations. The traps were set for four consecutive nights, giving a total of 800 trap-nights in each vegetation association. The Sherman, Elliott and break-back traps were set close to each other on the ground and the funnel trap was suspended in vegetation up to 2 m above the ground.

All *S. leucopus*, *A. stuartii* and *R. lutreolus* captured alive were released at the point of capture after being individually numbered by toe-clipping. All *M. musculus* and the one *Rattus rattus* captured were removed from the field. One hundred and forty-one *M. musculus* and 1 *R. rattus*, as well as 15 *A. stuartii*, 1 *S. leucopus* and 3 *R. lutreolus* found dead in the traps were lodged in the Western Australian Museum. The results of trapping are shown in Table 3. *M. musculus* and *A. stuartii* were trapped in all vegetation associations; *R. lutreolus* in all but *L. laevigatum* scrub; *S. leucopus* in the foredune complex and *E. viminalis* woodland, and the one *R. rattus* in the foredune complex. The numbers of individuals of each species captured in each vegetation association (Table 3) show that *M. musculus* was the species most commonly trapped (157 individuals), but fewer were trapped in *L. laevigatum* scrub than in the other 3 associations. The second most commonly trapped species was *A. stuartii* (40 individuals), the largest number being taken in *E. viminalis* woodland. The numbers of *R. lutreolus* (14 individuals), *R. rattus* (1 individual) and *S. leucopus* (3 individuals) were much lower, and none of these was taken in *L. laevigatum* scrub.

As in previous years, trapping success for *S. leucopus* was very low (0.5% in the foredune complex) even though a variety of live traps was used. Whether this reflects the rarity of the species or its trap shyness cannot be assessed, but it is in accord with the results of other workers (see Cheetham & Wallis 1981). Because trapping success was the same in 1974 as in 1971-72 it seems unlikely that the removal of 5 individuals from Area A at the earlier date had affected population levels. The 3 *S. leucopus* were captured in Sherman traps (Table 3). *A. stuartii* were captured in all four types of traps, the Sherman traps being the most effective. *R. lutreolus* and *M. musculus* were trapped in Sherman, Elliott and break-back traps. Sherman and Elliott traps were equally effective in capturing *R. lutreolus* but only

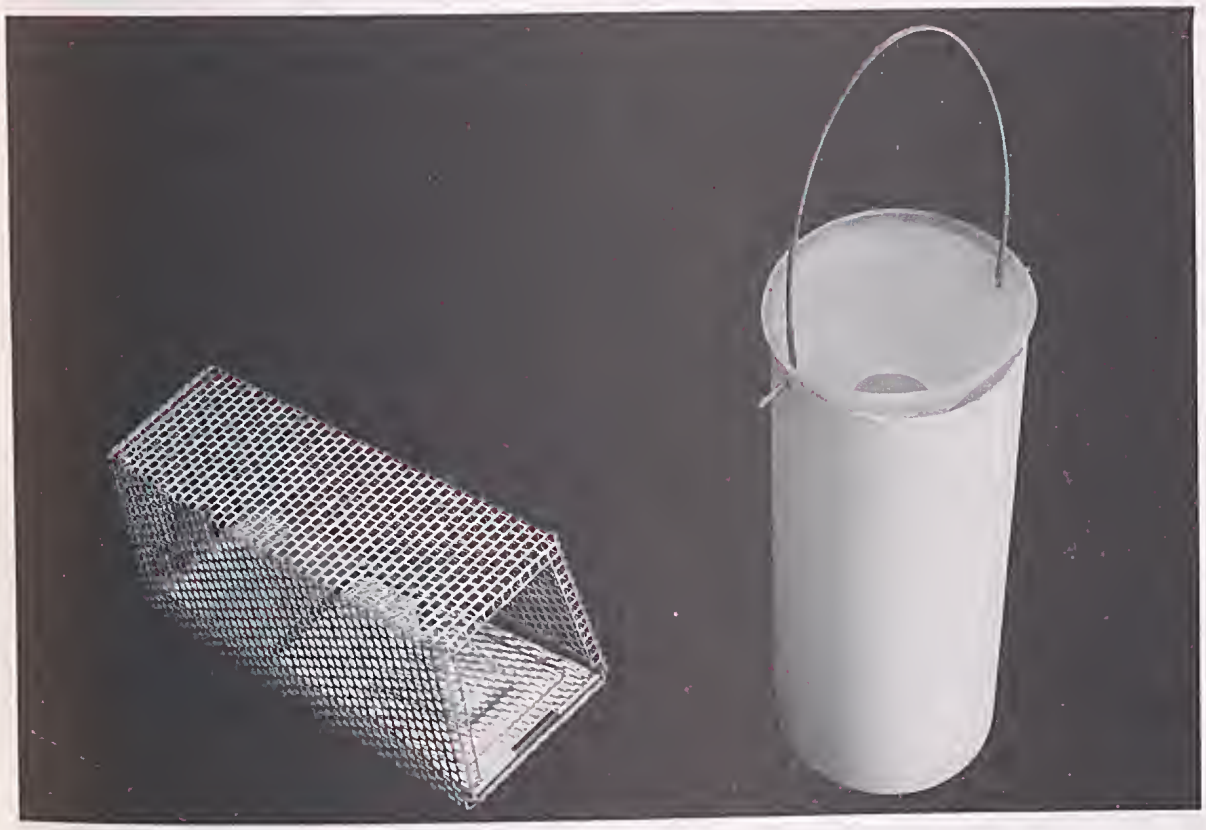

Fig. 3—The two specially designed live traps (Elliott box trap and funnel trap) used in 1974.

Table 3
Results of Trapping in 1974 to Test Trap Effectiveness and Habitat Preference

Vegetation Association	Type of trap	No each species trapped				
		S.l.	*A.s.*	*R.l.*	*R.r.*	*M.m.*
Foredune complex (A)	S	2	7	4	0	10
	E	0	5	6	1	26
	F	0	0	0	0	0
	B	0	0	0	0	22
	Total	2(2)	13(4)	10(5)	(1)	(58)
L. laevigatum scrub	S	0	11	0	0	4
	E	0	1	0	0	3
	F	0	1	0	0	0
	B	0	4	0	0	6
	Total	0	17(9)	0	0	(13)
E. viminalis woodland	S	1	15	3	0	11
	E	0	3	4	0	6
	F	0	0	0	0	0
	B	0	7	1	0	30
	Total	(1)	25(19)	8(6)	0	(47)
B. integrifolia woodland	S	0	7	5	0	6
	E	0	3	1	0	12
	F	0	0	0	0	0
	B	0	0	0	0	21
	Total	0	10(8)	6(3)	0	(39)

Trap types: S = Sherman, E = Elliott, F = Funnel and B = Break-back. Abbreviation of species names as in Table 1, plus *R.r.* = *Rattus rattus*. The total number of each species trapped includes recaptures. The figures in brackets represent the number of individuals.

one of this species was caught in a break-back trap. Most of the *M. musculus* were captured in break-back traps. The one *R. rattus* captured was in an Elliott trap. Only one animal (an *A. stuartii*) was captured in the funnel traps. Of the three types of live traps tested, Sherman traps were found to be the most effective for the capture of *S. leucopus* and *A. stuartii*, and as effective as Elliott traps for the capture of *R. lutreolus* and *M. musculus*.

The one *S. leucopus* trapped in *E. viminalis* woodland, which was found dead in the trap, was misidentified as *A. stuartii* until after the completion of trapping in 1974. Thus it appeared from the habitat preference study, and from the results of trapping in previous years, that *S. leucopus* was found only in the foredune complex. Because all species were thought to occur together only in the foredune complex the study of distribution and home range of the small mammals was carried out in that vegetation association, using Sherman traps.

Distribution and home range of the small mammals in the foredune complex

Part of area B of the foredune complex was selected for this study (grids, Fig. 1A). In area B, the grassland does not extend along the length of the foredune complex, which in parts has been eroded by wave and wind action with the formation of cliffs up to 2 m high. The distance between high water mark and the *L. laevigatum* scrub varies from 20 to 90 m. To examine the distribution of mammals in the two major plant communities within the complex it was necessary to set the traps on two adjacent grids. One grid, with 20 trap sites, was in grassland and the other, with 80 trap sites, in the *Acacia-Leptospermum* community and edge of the *L. laevigatum* scrub. The positions and dimensions of the two grids are shown in Figure 1B. One hundred Sherman traps (50 large, 50 small) were used. One trap was located at each trap site and large and small traps were placed 20 m apart on alternate lines within the grids. The traps were baited as above and in all but one of the 11 trapping periods between June and October were set for 2 consecutive nights; in the seventh period they were set for one night only, giving a total of 2 100 trap-nights. They were inspected early each morning. Between trapping periods they were left closed and unbaited. Three species of mammals (*S. leucopus*, *A. stuartii* and *M. musculus*) were captured. All were individually

numbered by toe-clipping at first capture and released at the point of capture. The failure to capture *R. lutreolus* in this study suggests that the distribution of this species within the foredune complex is patchy and that the grids did not encompass the territory of any. Observations made on the reproductive condition of the *S. leucopus* will be considered below.

In the 11 trapping periods 31 *S. leucopus* (9 individuals—6 males, 3 females), 5 *A. stuartii* (2 individuals—1 male, 1 female) and 43 *M. musculus* (17 individuals) were captured. It can be seen that *S. leucopus* and *M. musculus* were trapped in both the grassland (small grid) and shrub communities (large grid) of the foredune complex but *M. musculus* was trapped most frequently in the grassland and *S. leucopus* in the shrubland (Fig. 4A). *S. leucopus* was also trapped on the edge of the *L. laevigatum* scrub (trap line 1-15), which was the only part of the grid on which *A. stuartii* was captured.

Some individuals were captured more than once during the study. The trap sites at which these individuals were captured are shown in Figure 4B for *S. leucopus* and in Figure 4C for *M. musculus*. Considerable overlap in the range of individuals can be seen. The maximum distance between sites of capture for an individual *S. leucopus* was 260 m, for *A. stuartii* 60 m, and for *M. musculus* 200 m. The maximum range length for *S. leucopus* was more than twice that recorded by Cheetham and Wallis (1981). Some individuals were captured at different trap sites on consecutive nights in one or more trapping periods and in these cases the distances between sites of capture were as follows: *S. leucopus* male 2 (20 m, 90 m), female 3 (20 m, 60 m), male 4 (80 m, 90 m) and *M. musculus* 6 (40 m), 14 40 m). One *S. leucopus* (male 2) was recaptured within 1 hour of release 90 m from the site at which it was released. The longest periods between captures of individuals of the three species during the 18 weeks of the study were as follows: *S. leucopus* male 1 (11 weeks), female 3 (13 weeks); *A. stuartii* female 2 (6 weeks) and *M. musculus* 2 (16 weeks).

A trapping success of 0.4% for *S. leucopus* (individuals) on the grids suggests that the population density had not been greatly affected by the removal of 17 animals (14 in 1973 and 3 in 1972) from area B of the foredune complex.

Trapping in March 1975

Fifty large Sherman traps baited with bacon and peanut butter were set for 3 nights in the foredune complex (area B) with the object of collecting *S. leucopus* for study of their reproductive condition. Four *S. leucopus* (2 male, 2 female) and 9 *M. musculus* were captured.

REPRODUCTION

Animals and Methods

Forty-nine *S. leucopus* (39 male, 10 female) were captured between November 1971 and March 1975. Observations on the reproductive condition of the majority of these animals were made in the field at the time of initial capture and at any subsequent recapture. The width of the scrotum of males was measured, the pouch area of females inspected, and an attempt made to obtain a urine sample which was examined for the presence of spermatozoa in males or epithelial cells, which are indicative of oestrus, in females. The animals were also weighed.

Fourteen (11 male, 3 female) of the 49 individuals captured were maintained in the laboratory. One of the females had 8 young (5 male, 3 female) in the pouch when trapped and these were reared in the laboratory. Another female, trapped at Boneo Swamp near Rosebud, Victoria in 1974 was also held, bringing the total number of animals maintained in the laboratory to 23 (16 male, 7 female). Eight were held for less than 6 months, 8 for between 6 and 12 months, and 7 for longer than 12 months, the maximum period for any individual being 16 months. With the exception of the female with young, which was housed in a wooden cage with a floor area of 1 m², they were housed in glass-fronted stainless steel cages with wire mesh backs and tops and detachable nest boxes, and fed a minced chicken meat mixture supplemented with insects (Woolley 1982). The observations made on animals at the time of capture (see above) were made at intervals of 1 to 2 weeks, or more frequently in the case of females once epithelial cells were detected in the urine, on animals maintained in the laboratory.

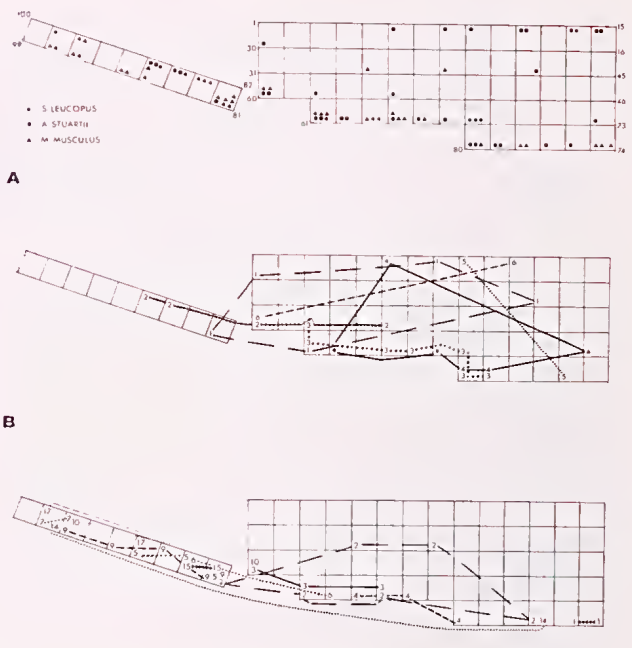

Fig. 4—A, sites of capture of *S. leucopus*, *A. stuartii* and *M. musculus* on the trapping grids in the foredune complex in 1974. B, sites of capture and range of individual *S. leucopus*. C, sites of capture and range of individual *M. musculus*.

Observations on the gross and histological appearance of the reproductive organs were made on 21 (15 male, 6 female) of these animals and on another 10 (6 male, 4 female) which were either found dead in the traps or were killed soon after capture. In males, the greatest width of the prostate (or membranous urethra in immature animals) was measured. One uterus of females in breeding condition was opened in saline and examined for the presence of eggs. Tissues for histological examination were fixed in Bouin's solution, stored in 70% alcohol, embedded in paraffin wax, sectioned at 8 or 10 μm and stained with haemotoxylin and eosin. Representative 10 μm sections were prepared from one testis from each male. Ovaries were serially sectioned at 8 μm and one diameter of Graafian follicles and of corpora lutea was calculated by counting the number of sections each appeared in and multiplying this number by 8.

Results

Males: The same pattern of changes in body weight and scrotal width can be seen in laboratory reared and field animals, as well as in wild-caught males during their first year in the laboratory (Fig. 5). Body weight is maximal in August and September and scrotal width in June, July and August. In these males spermatorrhoea commenced in June or July and continued in some until November. Four wild-caught males maintained in the laboratory into a second year could be distinguished by their greater body weight and scrotal width in the early months of the year. Two of these males, maintained until August, showed no recurrence of spermatorrhoea. With the exception of the two second year males prostatic thickening of the urethra was not evident until July (Fig. 5). In later months of the year all males had large prostates, which is illustrated by the width of the gland.

Histological examination of testes of males, other than those in their second year in the laboratory, revealed that spermatogenesis was occurring in all sampled in June and July, and in some as late as October. The seminiferous tubules were open and all cell types were present in the germinal epithelium. Spermatogenic activity had ceased in some males as early as August, and in others in September, October and December. The seminiferous tubules of these males contained only Sertoli cells; in some the tubules remained open, in others

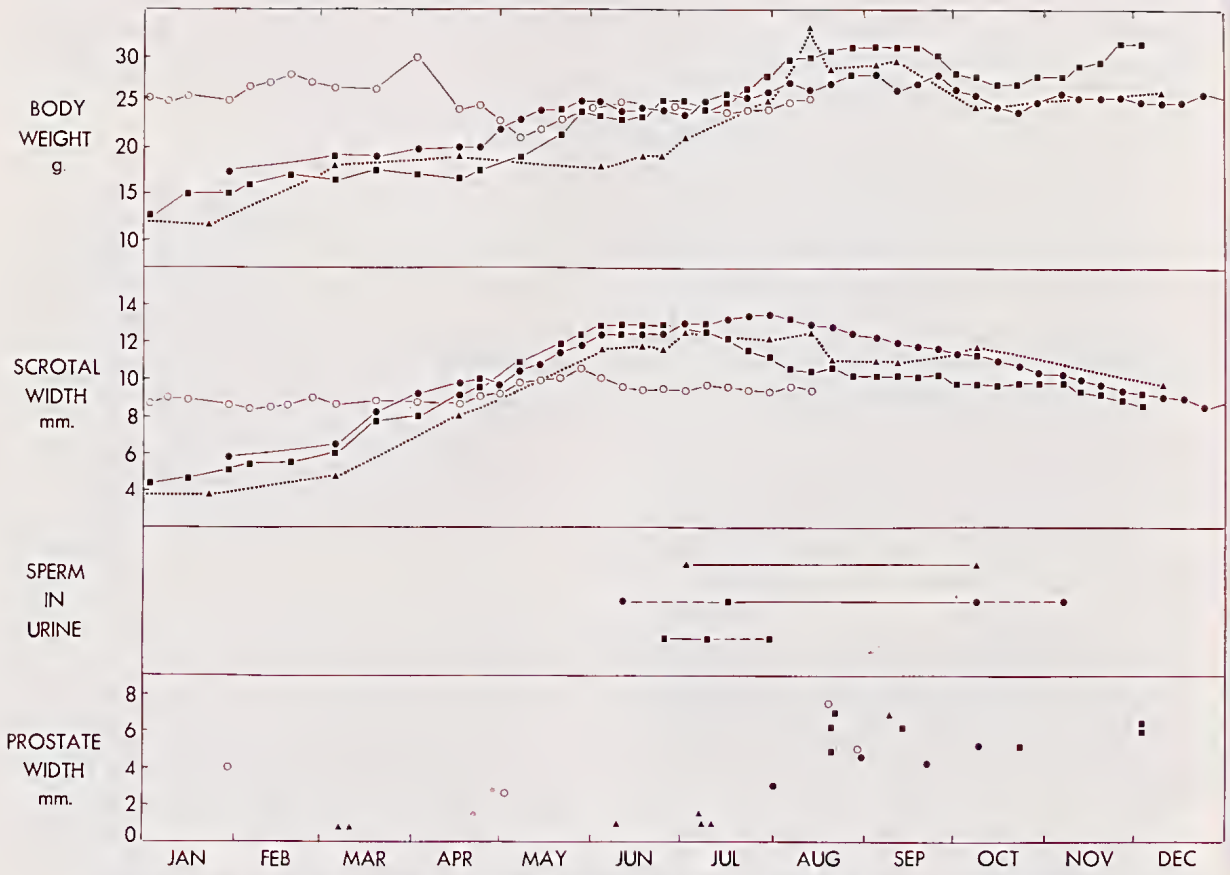

Fig. 5 — Body weight and reproductive condition of male *S. leucopus*. The broken line (sperm in urine) indicates that not all individuals sampled were showing spermatorrhoea. Points represent the means for all animals examined (range 1 to 17). ▲ field animals, ● laboratory colony — first breeding season, ○ laboratory colony — second breeding season, ■ laboratory reared — first breeding season.

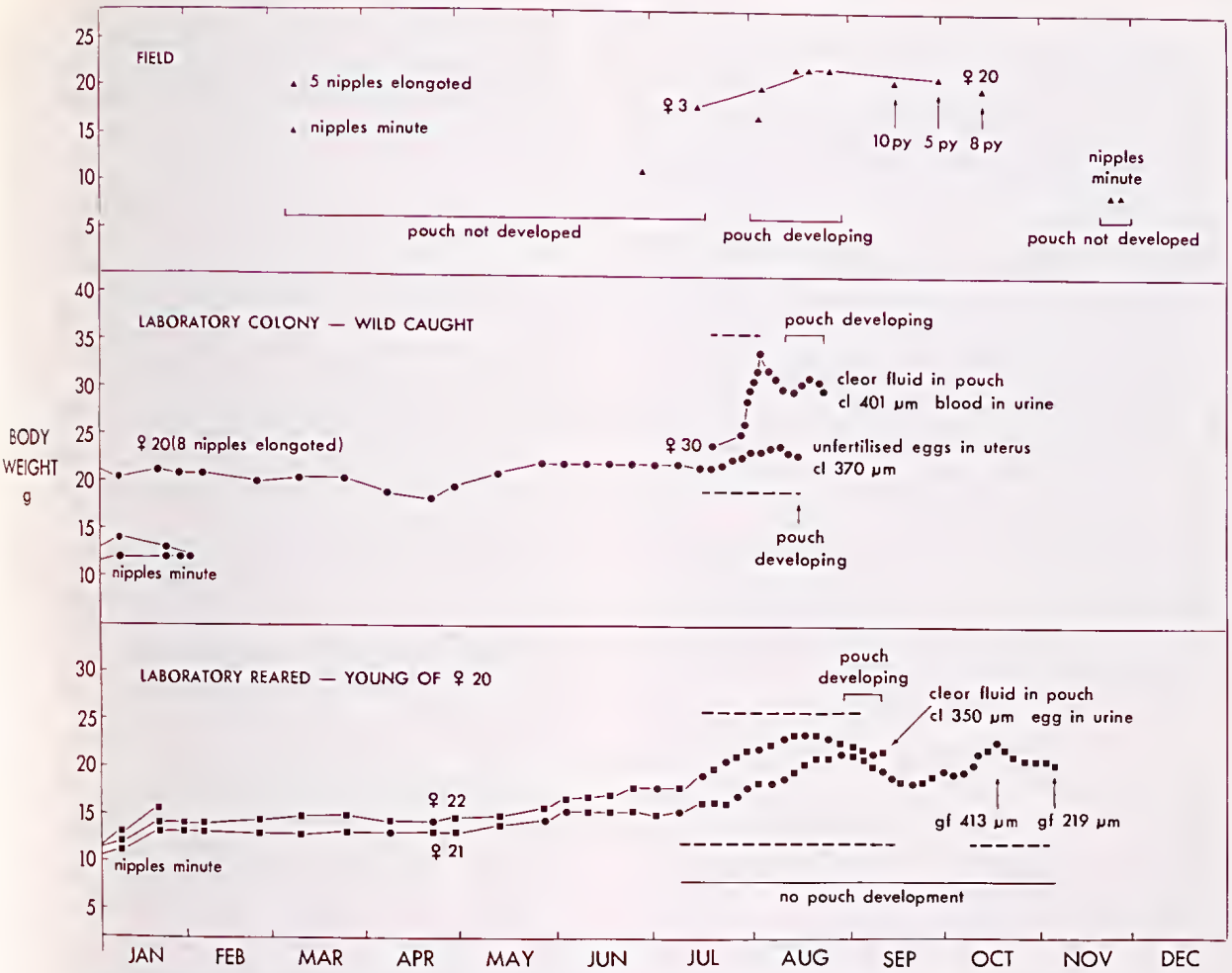

Fig. 6—Body weight and reproductive condition of female *S. leucopus*. Two field animals (one of which was recaptured several times and one of which was removed from the field) and four of those maintained in the laboratory are identified by number. Broken lines indicate the presence of epithelial cells in the urine of individual females.

they were closed. The seminiferous tubules of males sampled in March, that could be recognised as juveniles by their body weight and scrotal width, were closed and contained Sertoli cells, spermatogonia and a few spermatocytes. The seminiferous tubules of males in their second year, sampled in January, May and August, contained only Sertoli cells.

Females: S. leucopus has a Type 3 pouch (Woolley 1974) and all females examined had 10 nipples. The body weight and appearance of the pouch and nipples at capture of 10 females including one (female 3) which was recaptured several times is shown in Figure 6. Three females trapped in August were showing pouch development characteristic of pregnancy. One of these (female 3) and another 2 individuals were carrying young in the pouch when trapped in September and October. None of the 6 females trapped in March, June, July and November was carrying pouch young or showing pouch development. Of these only one, captured in March, had elongated nipples characteristic of females that have previously suckled young.

Also shown in Figure 6 is the body weight and reproductive condition of 4 wild-caught and 3 laboratory reared females maintained in the laboratory. Epithelial cells first appeared in the urine of females in July. These oestrous females were housed with males but no matings were observed and no spermatozoa were detected in urine samples obtained from the females. Development of the pouch, preceded or accompanied by an increase in body weight, was seen in late August in 3 of the 4 females. Only an increase in body weight, was seen in the fourth. The reproductive organs of these females were examined to obtain further information on their reproductive condition. Two were killed when the appearance of clear fluid (milk) in the pouch signalled the end of pregnancy (or pseudopregnancy). In one of these females (30) there was blood in the urine and in the other (22), an undeveloped egg, both signs that 'parturition' had occurred. No eggs or embryos were found in

the enlarged uteri of these females, but both had large corpora lutea in the ovaries (14 in female 30, 11 in female 22). One female (20), killed before pouch development was maximal had unfertilised eggs in the uteri and 14 large corpora lutea in the ovaries. The one female (21) which did not show pouch development appeared to enter oestrus for a second time in October when epithelial cells appeared in the urine and body weight rose again. One ovary surgically removed from this female in mid-October contained 7 large Graafian follicles. When killed in early November, 7 degenerating Graafian follicles were found in the remaining ovary. There were no corpora lutea, and no eggs in the uteri.

An estimate of the gestation period in *S. leucopus* can be obtained from the observations made on female 30. In both unmated and mated females of other species (e.g. in *Antechinus stuartii*, Selwood 1980 and *S. macroura*, Woolley unpub.) a fall in body weight and a decline in epithelial cells in the urine has been correlated with ovulation. A second weight drop occurs in association with the onset of milk production and parturition (Woolley 1966, 1971). In *S. leucopus* female 30 the interval between disappearance of epithelial cells from the urine (and weight drop) and the secretion of milk (and a second weight drop) was 20 days.

The ovaries of 6 females, collected between January and early August were examined histologically. One obtained in January, one in February and two in March contained large numbers of small follicles with only a single layer of granulosa cells. One obtained in June contained follicles with up to 5 layers of granulosa cells and one in very early August, large follicles in which antrum formation had only just commenced. This female had epithelial cells in the urine, the rim of the pouch was slightly thickened and the nipples were red, indicating that she was in oestrus.

Except during the breeding period adult females (i.e. females that have reared young) can be distinguished from juveniles by their elongated nipples and by their greater body weight.

DEVELOPMENT OF THE YOUNG

Female 20, captured in mid-October with 8 pouch young (5 males, 3 females) estimated to be 3-4 weeks old, reared her litter in the laboratory. The young were weaned in late November, when the body weight (*ca* 9.0 g) of the females in the litter was comparable to that of 2 females captured in late November (see Figure 6) which were considered to be newly independent young. Males were up to 2 g heavier than females at weaning and their weight was comparable to that of a juvenile male captured in early December (not shown in Figure 5). One female young died in January; the other 7 young reached sexual maturity in July-August, at an age of about 11 months.

DISCUSSION

S. leucopus males appear to have only one short breeding season, commencing in late winter, in their lifetime. Sperm production occurs from June to October but the prostate does not reach maximal size until August, which suggests that mating would not be successful before then. Thus the potential for breeding appears to be limited to a period of about 3 months. The absence of adult males from the trap returns in the early months of the year, together with the failure of males maintained in the laboratory for a second year to produce sperm, suggests that they do not normally survive to breed in a second year. However, their presence in the field for some time after the birth of the young shows that they do not experience the rapid 'die-off', in which all males die before the young are born, that occurs in some dasyurids that are seasonally restricted breeders (Lee *et al.* 1982). Lunney (1982) also has found that adult males are present in the population after the birth of the young. However, they had disappeared within a month of the young becoming independent.

Female *S. leucopus* were observed to enter oestrus in July and early August. Three females with pouch young were captured in September and October. These young were estimated, by comparison of their size with that of known age young of other species of *Sminthopsis*, to have been born in late August or September. In the laboratory, 'parturition' occurred in late August and early September. If gestation occupies about 3 weeks these observations suggest that mating occurs in August, at which time the males (see above) appear to reach breeding condition. In the field no evidence was found of breeding at other times of the year but in the laboratory one female, maintained beyond the time of expected birth entered oestrus for a second time. Although this female did not show pouch development characteristic of pregnancy, and therefore may have been abnormal, the possibility exists that females may undergo a second oestrus if unmated, or after premature loss of the first litter of the season. Whether or not this usually occurs could be simply determined by monitoring the reproductive condition of unmated females in the laboratory between July and November. Some advantage in the survival of males for several months after the onset of breeding, and beyond the time when births are known to occur, can be seen if the females are polyoestrous.

This analysis of the pattern of reproduction raises difficulties for the inclusion of *S. leucopus* in the group of species exhibiting the second of the life history strategies defined by Lee *et al.* (1982). Even if the females are found to be monoestrous, no males survive to breed in a second year, as they do in other species exhibiting this strategy.

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leucopus for the laboratory colony and R. Parsons made available aerial photographs of the study area. Permission to trap and collect animals was granted by the Victorian Fisheries and Wildlife Division. Financial assistance from the M. A. Ingram Trust in 1973 is gratefully acknowledged.

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Note added in proof

Observations by Read *et al.* (1982) on 1 female support the conclusion that *S. leucopus* may be polyoestrous. This female produced a single pouch young on 1st September. The young was removed and she returned to oestrus and mated on 29th September, 11 days after parturition. No young resulted from the mating and she returned to oestrus again on 28th October, but did not mate.

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